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EXAMINER

SONG, MATTHEW J

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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/009,910
Filing Date: December 12, 2001
Appellant(s): IIDA ET AL.

John Scherlacher
For Appellant

EXAMINER'S ANSWER

MAILED

DEC 23 2005

GROUP 1700

This is in response to the appeal brief filed 9/26/2005 appealing from the Office action mailed 6/24/2004.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

5,968,264	Iida et al.	10-1999
6,277,501	Fujikawa	8-2001
6,162,708	Tamatsuka et al.	12-2000
5,954,873	Hourai et al.	9-1999

6,641,888

Asayama et al.

11-2003

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

1. Claim 9 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 9 recites, "in which oxygen precipitation nuclei of 1×10^9 " in line 4. There is no support for oxygen precipitation nuclei. The instant specification merely teaches a BMD density of 1×10^9 , note page 13 of the specification.

2. Claims 1 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (US 5,968,264) in view of Fujikawa (US 6,277,501).

Iida et al discloses a method of forming a silicon wafer with an N region formed over the entire surface by pulling a crystal from a silicon melt in a Czochralski method at a pulling rate, V, ranging between 0.55-0.58 mm/min and a G ranging from 42.0-45.0 °C/cm from the center to the edge of the silicon ingot, this reads on applicant's controlling V/G because V and G are controlled, therefore the ratio is inherently controlled (Example 1 and 2). Iida et al also discloses in order to establish the N region over the entire cross section of a crystal, a highly precisely control must be carried out. Also note that the entire reference has been incorporated into the basis of the rejection.

Iida et al does not disclose the silicon single crystal is pulled while doping with carbon.

In a method of forming a silicon wafer, note entire reference, Fujikawa teaches growing a silicon single crystal while controlling the oxygen concentration in the range of 12×10^{17} - 18×10^{17} atoms/cm³ and controlling the carbon concentration in the range of 0.3×10^{16} - 2.5×10^{16} atoms/cm³ (col 9, ln 1-67), where 2.5×10^{16} atoms/cm³ of carbon approximately corresponds to 0.5 ppma (col 5, ln 1-67). Fujikawa also teaches annealing a wafer, containing specified amounts of oxygen and carbon, is annealed at 600-900°C for at least more than 15 minutes to achieve a BMD of over 3×10^8 /cm³ (col 11, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Iida et al with Fujikawa to promote precipitation of oxygen, thereby producing an epi-wafer without an expensive EG treatment (col 6, ln 1-67 and col 7, ln 1-67).

The combination of Iida et al and Fujikawa et al is silent to the silicon single crystal being pulled at a rate greater than the rate of pulling a silicon single crystal with no carbon doping. Iida et al teaches through the adequate adjustment of the pulling rate, the N region can be formed over the entire crystal cross section (col 5, ln 10-15), which is a teaching that pulling rate is a result effective variable for forming a N-region. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Iida et al and Fujikawa et al by optimizing the pulling rate to obtain a pulling rate greater than the rate of pulling a silicon single crystal with no carbon doping conducting routine experimentation of a result effective variable.

Referring to claim 5, the combination of Iida et al and Fujikawa teaches annealing at 600-900°C, overlapping ranges are held to be obvious (MPEP 2144.05).

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3. Claims 2, 6, 9-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (5,968,264) in view of Fujikawa (US 6,277,501) as applied to claim 1 above, and further in view of Tamatsuka et al (US 6,162,708).

The combination of Iida et al and Fujikawa teaches all of the limitations of claim 2, as discussed previously in claim 1, except the silicon single crystal is doped with nitrogen.

In a method of forming an epitaxial silicon wafer, note entire reference, Tamatsuka et al teaches a silicon single crystal doped with nitrogen in the range of 1×10^{10} to 5×10^{15} atoms/cm³ and an interstitial oxygen concentration in the single crystal ingot is 18 ppma or less (col 2, ln 1-67). Tamatsuka et al also teaches annealing at 900°C (col 8, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Iida et al and Fujikawa with Tamatsuka et al because a silicon single crystal wafer produced by doping nitrogen during growth of the silicon crystal ingot has a high gettering capability, growth of grown in defects incorporated can be suppressed and density of oxide precipitates can be increased (col 6, ln 1-67).

Referring to claim 6, the combination of Iida, Fujikawa and Tamatsuka et al teaches annealing at 600-900°C. Overlapping ranges are held to be obvious.

Referring to claim 9, it is noted that claim 9 is a product claim, which recites process limitations. The patentability determination of a product-by-process claim is based on the patentability of the product and does not depend on its method of production (MPEP 2113). Therefore, the product taught by the combination of Iida, Fujikawa and Tamatsuka et al reads on the instantly claimed silicon wafer because the product limitations are taught by the combination of Iida, Fujikawa and Tamatsuka et al. The combination of Iida, Fujikawa and Tamatsuka et al

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teaches annealing to achieve a BMD of over $3 \times 10^8/\text{cm}^3$ this reads on applicants oxygen precipitation nuclei because applicants teach a BMD density, note page 13 of the specification. Overlapping ranges are held to be obvious (MPEP 2144.05).

4. Claims 3 and 7 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (US 5,968,264) in view of Fujikawa (US 6,277,501) as applied to claim 1 above, and further in view of Hourai et al (US 5,954,873).

The combination of Iida et al and Fujikawa teaches all of the limitations of claim 3, as discussed previously, except controlling V/G within a range of $0.183\text{-}0.177 \text{ mm}^2/\text{K min}$.

Hourai et al discloses a V/G ratio of $0.183\text{-}0.177 \text{ mm}^2/\text{K min}$ (Fig 2), where dislocation clusters form through the entire wafer, this reads applicant's N-region, where wafers are formed from a silicon single crystal ingot manufactured by the Czochralski method with careful control of the pulling rate and temperature gradient permit a crystal to be formed that is free of Oxidation induced stacking fault rings and other defects (Abstract). Hourai et al also teaches V and G are important parameters for controlling the diameter of an OSF ring (col 4, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Iida et al and Fujikawa with Hourai et al because a larger V/G allows the crystal to be pulled faster, thereby increasing production.

5. Claims 4 and 8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (US 5,968,264) in view of Fujikawa (US 6,277,501) and Tamatsuka et al (US 6,162,708) as applied to claim 2 above, and further in view of Hourai et al (US 5,954,873).

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The combination of Iida et al, Fujikawa and Tamatsuka et al teaches all of the limitations of claim 4, as discussed previously, except controlling V/G within a range of 0.183-0.177 mm²/K min.

Hourai et al discloses a V/G ratio of 0.183-0.177 mm²/K min (Fig 2), where dislocation clusters form through the entire wafer, this reads applicant's N-region, where wafers are formed from a silicon single crystal ingot manufactured by the Czochralski method with careful control of the pulling rate and temperature gradient permit a crystal to be formed that is free of Oxidation induced stacking fault rings and other defects (Abstract). Hourai et al also teaches V and G are important parameters for controlling the diameter of an OSF ring (col 4, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Iida et al, Fujikawa and Hourai et al with Hourai et al because a larger V/G allows the crystal to be pulled faster, thereby increasing production.

6. Claims 1, 3, 5, 7 and 9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hourai et al (US 5,954,873) in view of Fujikawa (US 6,277,501).

Hourai et al discloses a V/G ratio of 0.183-0.177 mm²/K min (Fig 2), where dislocation clusters form through the entire wafer, this reads applicant's N-region, where wafers are formed from a silicon single crystal ingot manufactured by the Czochralski method with careful control of the pulling rate and temperature gradient permit a crystal to be formed that is free of Oxidation induced stacking fault rings and other defects (Abstract). Hourai et al also teaches V and G are important parameters for controlling the diameter of an OSF ring (col 4, ln 1-67). Also note the entire reference has been incorporated into the basis of the rejection.

Hourai et al does not disclose the silicon single crystal is pulled while doping with carbon

In a method of forming a silicon wafer, note entire reference, Fujikawa teaches growing a silicon single crystal while controlling the oxygen concentration in the range of 12×10^{17} - 18×10^{17} atoms/cm³ and controlling the carbon concentration in the range of 0.3×10^{16} - 2.5×10^{16} atoms/cm³ (col 9, ln 1-67), where 2.5×10^{16} atoms/cm³ of carbon approximately corresponds to 0.5 ppm (col 5, ln 1-67). Fujikawa also teaches annealing a wafer, containing specified amounts of oxygen and carbon, is annealed at 600-900°C for at least more than 15 minutes to achieve a BMD of over 3×10^8 /cm³ (col 11, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Hourai et al with Fujikawa to promote precipitation of oxygen, thereby producing an epi-wafer without an expensive EG treatment (col 6, ln 1-67 and col 7, ln 1-67).

The combination of Hourai et al and Fujikawa et al is silent to the silicon single crystal being pulled at a rate greater than the rate of pulling a silicon single crystal with no carbon doping. Hourai et al teaches careful control of the pulling rate permits a crystal to be formed that is free of Oxidation induced stacking fault rings and other defects (Abstract), which is a teaching that pulling rate is a result effective variable for forming a N-region. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Hourai et al and Fujikawa et al by optimizing the pulling rate to obtain a pulling rate greater than the rate of pulling a silicon single crystal with no carbon doping conducting routine experimentation of a result effective variable.

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Referring to claim 3, 5 and 7, the combination of Hourai et al and Fujikawa teaches a carbon concentration of 0.5 ppma and a V/G of 0.183-0.177 mm²/K min and annealing at a temperature of 600-900°C. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 9, the combination of Hourai et al and Fujikawa teaches a wafer with dislocation clusters throughout the wafer pulled under a similar V/G condition, as applicant, therefore this reads on applicant's N-region. And a carbon concentration of 0.5 ppma. Also, it is noted that claim 9 a product claim, which recites process limitations. The patentability determination of a product-by-process claim is based on the patentability of the product and does not depend on its method of production (MPEP 2113). Therefore, the product taught by the combination of Hourai et al and Fujikawa et al reads on the instantly claimed silicon wafer because the product limitations are taught by the combination of Hourai et al and Fujikawa et al. The combination of Hourai et al and Fujikawa teaches annealing to achieve a BMD of over $3 \times 10^8/\text{cm}^3$, this reads on applicant's oxygen precipitation nuclei because applicants teaches BMD density, note page 13 of the instant specification. Overlapping ranges are held to be obvious (MPEP 2144.05).

7. Claims 2, 4, 6, 8 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hourai et al (US 5,954,873) in view of Fujikawa (US 6,277,501) as applied to claim 1 above, and further in view of Tamatsuka et al (US 6,162,708).

The combination of Hourai et al and Fujikawa teaches all of the limitations of claim 2, as discussed previously in claim 1, except doping with nitrogen.

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In a method of forming an epitaxial silicon wafer, note entire reference, Tamatsuka et al teaches a silicon single crystal doped with nitrogen in the range of 1×10^{10} to 5×10^{15} atoms/cm³ and an interstitial oxygen concentration in the single crystal ingot is 18 ppma or less (col 2, ln 1-67). Tamatsuka et al also teaches annealing at 900°C (col 8, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Hourai et al and Fujikawa with Tamatsuka et al because a silicon single crystal wafer produced by doping nitrogen during growth of the silicon crystal ingot has a high gettering capability, growth of grown in defects incorporated can be suppressed and density of oxide precipitates can be increased (col 6, ln 1-67).

Referring to claims 6 and 8, the combination of Hourai, Fujikawa and Tamatsuka teaches annealing at 600-900°C, overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 10, the combination of Hourai, Fujikawa and Tamatsuka teaches a nitrogen content of 1×10^{10} - 1×10^{15} number/cm³, overlapping ranges are obvious.

8. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Asayama et al (US 6,641,888) in view of Iida et al (US 5,968,264) or Hourai et al (US 5,954,873).

Asayama et al teaches a silicon single crystal is doped with carbon and nitrogen and is sliced to from silicon wafers (Abstract). Asayama et al teaches a nitrogen concentration of 5×10^{13} atoms/cm³ and a carbon concentration of 3×10^{16} atoms/cm³ (Table 1 and Table 2). Overlapping ranges are held to be obvious (MPEP 2144.05). Asayama et al also teaches the wafers are heat treated at 1000°C (col 10, ln 30-40).

Asayama et al is silent to the silicon single crystal is pulled while controlling V/G to have an N-region over an entire plane of the crystal.

Iida et al discloses a method of forming a silicon wafer with an N region formed over the entire surface by pulling a crystal from a silicon melt in a Czochralski method at a pulling rate, V, ranging between 0.55-0.58 mm/min and a G ranging from 42.0-45.0 °C/cm from the center to the edge of the silicon ingot, this reads on applicant's controlling V/G because V and G are controlled, therefore the ratio is inherently controlled (Example 1 and 2). Iida et al also discloses in order to establish the N region over the entire cross section of a crystal, a highly precisely control must be carried out. Also note that the entire reference has been incorporated into the basis of the rejection. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Asayama et al with Iida's controlling V/G to form a silicon ingot with a desirable N-region over the entire cross section ('264 col 5, ln 1-20).

Hourai et al discloses a V/G ratio of 0.183-0.177 mm²/K min (Fig 2), where dislocation clusters form through the entire wafer, this reads applicant's N-region, where wafers are formed from a silicon single crystal ingot manufactured by the Czochralski method with careful control of the pulling rate and temperature gradient permit a crystal to be formed that is free of Oxidation induced stacking fault rings and other defects (Abstract). Hourai et al also teaches V and G are important parameters for controlling the diameter of an OSF ring (col 4, ln 1-67). Also note the entire reference has been incorporated into the basis of the rejection. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Asayama et al with Hourai's controlling V/G to form a silicon ingot with a desirable N-region over the entire cross section ('264 col 5, ln 1-20).

The combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al is silent to the silicon single crystal being pulled at a rate greater than the rate of pulling a silicon single crystal with no carbon doping. Iida et al teaches through the adequate adjustment of the pulling rate, the N region can be formed over the entire crystal cross section (col 5, ln 10-15), which is a teaching that pulling rate is a result effective variable for forming a N-region. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al by optimizing the pulling rate to obtain a pulling rate greater than the rate of pulling a silicon single crystal with no carbon doping conducting routine experimentation of a result effective variable.

Referring to claims 9-10, it is noted that claim 9 is a product claim, which recites process limitations. The patentability determination of a product-by-process claim is based on the patentability of the product and does not depend on its method of production (MPEP 2113). Therefore, the product taught by the combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al reads on the instantly claimed silicon wafer because the product limitations are taught by the combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al. The combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al is silent to the defect density if 1×10^9 number/cm³, however this is inherent because the combination of Asayama et al and Hourai et al or the combination of Asayama et al and Iida et al teaches a similar method of pulling a single crystal doped with similar amounts of dopants and annealing at a similar temperature, as applicants.

(10) Response to Argument

Appellant's arguments filed 9/26/2005 have been fully considered but they are not persuasive.

There are two issues regarding the rejection of the pending claims. The first is a 112 First Paragraph new matter rejection and the second is whether the invention would have been obvious to a person of ordinary skill at the time of the invention. The 112 First Paragraph rejection is maintained because the originally filed application does not teach the limitation of an oxygen precipitation nuclei of 1×10^9 number/cm³ required by Claim 9. There is no explicit teaching of the quantity of oxygen precipitation nuclei. There is only a teaching of the quantity of bulk microdefects (BMDs) is 1×10^9 number/cm³, which are formed from oxygen precipitation. The Examiner maintains that the quantity of oxygen precipitation nuclei cannot be implicitly determined from the quantity of BMDs. The second issue is whether a person of ordinary skill in the art would have been able to arrive at the present invention by conducting routine experimentation. Iida et al teaches forming an N-region across the entire diameter of a silicon ingot by controlling the V/G ratio and the optimal pulling condition is obtained by varying pulling rate and slicing the obtained ingot to observe defect generation based on pulling speed to determine the optimal pulling rate, note Example 1 and Fig 10A. Fujikawa teaches doping a silicon ingot with carbon. The Examiner maintains that doping a silicon ingot with carbon and growing an N-region by controlling the V/G ratio, as taught by Iida et al, the pulling rate can be determined to be greater than pulling a silicon single crystal with no carbon doping.

Appellant's arguments regarding the 112 First Paragraph rejection are noted but are not found persuasive. Appellant alleges that the oxygen precipitation nuclei are used to grow the BMDs and since the density of the grown BMDs is 1×10^9 number/cm³, the concentration of BMDs supports the density of oxygen precipitation nuclei of 1×10^9 numbers/cm³ (page 5). The Examiner maintains that the original disclosure does not teach a correlation between the number of oxygen precipitation nuclei and the number of BMDs; therefore the number of oxygen precipitation nuclei cannot be implicitly taught by specifying the number of BMDs. Also, BMDs are defined to be bulk microdefects due to oxygen precipitates, not oxygen precipitation nuclei. BMDs are formed from oxide precipitates, which are formed from oxygen precipitation nuclei, which further distances the relationship between the alleged support and the claimed limitation. It is also noted that Appellant teaches that BMD density is strongly dependant on initial interstitial oxygen concentration, note page 18, third full paragraph, which further strengths the Examiner's position that the number of BMDs cannot be used to implicitly teach the number of oxygen precipitation nuclei because other factors may contribute to the final density BMD and there is no direct correlation between oxygen precipitation nuclei and BMD density.

Appellant also alleges that in order to generate two oxide precipitates (BMDs), at least two oxygen precipitation nuclei are necessary (page 6, last paragraph). The instant specification does not teach this feature, which is the basis of the 112 first paragraph rejection. If this teaching was present then there would be implicit support but this feature is not taught or suggested. The Examiner maintains that without a specific teaching that oxygen precipitation nuclei cannot form more than one BMD and that oxygen precipitation cannot be formed from other source than

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oxygen precipitation nuclei, there cannot be implicit support for the claimed density oxygen precipitation nuclei based on the number of BMDs.

Appellant's do not challenge each U.S.C. 103 rejection separately because all of the rejection employ the same type of obviousness rejection that the increased pulling rate compared to an undoped silicon would have been determined through routine experimentation; therefore the Examiner will also treat all of the rejections as a whole, but focus primarily on the Iida et al based rejection.

Appellant's argument that experimentally changing the pulling rate in the case of carbon doping is erroneous is noted but is not found persuasive. Appellant suggests that the controlling of pulling rate, V , and observation of the distribution of crystal defects by splitting the grown crystal longitudinally may carried out only one at a time and with no change in temperature gradient, G ; therefore further experimentation of change of the pulling rate is meaningless because a person of ordinary skill in the art would have no idea of how to carry out the experimentation to change the pulling rate as in Iida irrespective of there being no change of the temperature gradient (page 9, first two full paragraphs). This argument is not persuasive because Appellant is suggesting that pulling rate, V , and the temperature gradient, G , are to be varying together, which is not required. Iida et al teaches in Example 1, the temperature gradient at the center is $45.0^{\circ}\text{C}/\text{cm}$ and the temperature gradient at the edge is $42.0^{\circ}\text{C}/\text{cm}$ are fixed and the pulling rate is varied between 0.4-1.0 mm/min. It is unclear why Appellant is suggesting that not varying the temperature gradient during the experimentation of varying the pulling rate would render the results meaningless. Clearly, based on a the teaching of Iida et al, a person of ordinary skill in the art would simply perform the steps taught by Iida et al to determine the optimal

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pulling rate by fixing the temperature gradient and varying the pulling rate. Furthermore, application of the scientific method to optimize a single variable, such as pulling rate, requires maintaining all other process variables constant while varying the desired variable to observe the effects of changes in the desired variable. Appellant's assertion that pulling rate and thermal gradient cannot be variable together is contrary to known procedures for optimization, where only a single variable is varied.

Appellant's argument that determining the distribution of crystal defects by splitting the crystal longitudinally cannot be done by routine experimentation is noted but is not found persuasive. The Examiner agrees no wafers are obtainable from a silicon ingot, which is sliced longitudinally, Fig 10A. However, Iida et al clearly teaches that the ingot can be sliced into wafers rather than slicing longitudinally to determine the pulling rate required to from an N-region, note column 14, lines 20-50 and Table 1. Therefore, the pulling rate can be determined by routine experimentation because useable wafers are obtained, contrary to Appellant's argument.

Appellant's argument that the present invention does not change the temperature gradient; therefore one skilled in the art would naturally think that a crystal with an N-region can be obtained by the pulling rate as known in the prior art is noted but is not found persuasive. Iida et al merely teaches a specific embodiment and a person of ordinary skill in the art would not expect the optimal pulling rate to be the same for all processes. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to determine the optimal pulling rate from the method of varying pulling rate to determine the distribution of crystal defects. Iida et al teaches the pulling rate and the temperature gradient are adjusted such

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that the crystal is grown in a neutral region, note claim 4, and is not limited to any particular embodiment, as suggested by appellant. Furthermore, the pulling rate taught by Iida et al would not result in a crystal having an N-region over an entire plane of the crystal for a carbon doped crystal, as alleged by Appellant; therefore a person of ordinary skill would be required to perform routine experimentation to determine the value for pulling rate required to form an N-region over an entire plane of the crystal and that value would inherently be larger than the value for an un-doped crystal.

In response to appellant's argument that it is impossible to control the value to the shifted range because the shift of the V/G value by carbon doping is unknown in Iida, Hourai or the other cited references, the fact that appellant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). The prior art teaches forming a silicon single crystal doped with carbon and a method of controlling V/G to form a N-region over the entire plane of the crystal. The pulling rate employed by appellant is within the range of pulling rates employed by Iida et al to determine the optimal pulling rate for forming the N-region; therefore the increased pulling rate for carbon doped silicon would have naturally flowed from the suggestion of the prior art.

In conclusion, Appellant's invention is the discovery of being able to pull an N-region over an entire plane of a silicon single crystal faster by doping with carbon relative to an un-doped crystal. Fujikawa teaches a method of growing a carbon doped silicon single crystal, note the abstract, and Iida teach a method of controlling the V/G ratio during growth to form an N-region over the entire plane of a silicon single crystal, note claim 4. The Examiner admits the

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prior art does not teach an N-region is pulled faster by doping with carbon than a silicon single crystal, which is not doped with carbon. However, the Examiner maintains that a person of ordinary skill at the time of the invention attempting to form a N-region in the carbon doped silicon single crystal taught by Fujikawa would have recognized that a faster pulling rate is required to achieve an N-region over the entire plane of the silicon single crystal. Using the optimal pulling conditions for forming a N-region over the entire plane of the silicon single crystal for an un-doped silicon crystal taught by Iida et al would not have resulted an N-region over the entire plane of the silicon single crystal. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to conduct routine experimentation to determine the optimal value for pulling rate, as taught by Iida et al in Example 1, to form an N-region over the entire plane of the silicon single crystal and a person of ordinary skill at the time of the invention would have discovered a faster pulling rate is required. The increase in pulling rate is not significantly different from the value for an un-doped crystal, 0.65 mm/min for a carbon doped crystal compared to 0.54 mm/min for an un-doped crystal, note page 12, lines 5-7 of the Appeal Brief. The increased pulling rate would have been obvious to a person of ordinary skill in the art because the pulling rate is varied between 0.4 to 1.0 mm/min, which encompasses the pulling rate used by Appellant, to determine the distribution of crystal defects and the pulling rate required to form an N-region, note Example 1 of Iida.

For the above reasons, it is believed that the rejections should be sustained.

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Respectfully submitted,


Matthew J Song
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Art Unit 1722



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December 12, 2005

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